Water conservation is dead: long live water conservation

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Abstract There are three demand management responses to imbalances in water demand and supply: conserve water, substitute potable water with a different source, and augment existing supplies. Of these, water conservation is both the most cost-effective and the most resource-use-effective *i.e.* it saves materials and energy required for treatment, distribution, use and collection. Great examples of water conservation abound across the spectrum of water users. New water users in residential, industrial, institutional and commercial scenarios likely present better water saving investment opportunities, but retrofits are essential to reduce current water use. However, actions to date represent just the tip of the water conservation iceberg. What is needed for it to reach its potential is a clear approach that enables water utilities to unlock its potential, and confidently build it into planning processes. We have developed, applied and evaluated a demand management framework to enable this. The key elements of the framework are end use modelling and demand management options analysis to create new, more accurate, forecasts. The framework enables water authorities to identify meaningful local drivers and targets, and to be able to disaggregate current water end uses in their jurisdiction in order to identify the most cost-effective order of investment.

Keywords Water conservation, demand management, levelised cost, least cost planning

Introduction

Water is a finite resource. Existing potable water supplies are reaching their limits in terms of supplying current dependent populations. Demand for water continues to grow because of increasing populations, growing economies, and increasing recognition of the need to provide environmental flows. Meanwhile, climate change influences the reliability of the resource. There are three qualitatively different responses to this highly constrained situation:

1. increase water use efficiency (i.e. decrease demand, perhaps even to the point of moving to water free services);
2. substitute potable water with treated water of adequate quality; or
3. find new potable water sources (i.e. new dams or desalination plants).

We view all three of these (water conservation, source substitution, source augmentation) as potential contributors to demand management (DM). Some combination of all three will likely be necessary in the long term. Our interest is in where to focus in the short term to provide the best long term social, economic and environmental outcomes.

Current thinking in the water industry seems to be that ‘we’ve done water conservation’, and that we should therefore focus on ‘more important’ issues such as large-scale reuse or rainwater tank rebates. Our view is that the obituary for water conservation has been written far too early. We see water conservation as an iceberg: only the tip is visible from our usual vantage point and there is very much more than meets the eye. Moreover, water conservation and the extensive menu of options available to form water conservation programs provide water at both a lower unit cost and a higher resource use intensity than source substitution or new supply options, enabling valuable outcomes from societal, economic, and environmental perspectives. Therefore, we should invest in water conservation opportunities first.

Our first aim in this paper is to reveal the full scale of the water conservation iceberg. Our second aim is to explain a coherent and rigorous process that we have used to enable water managers to access the rest of the iceberg. The process brings together two key ideas to unlock the full range of DM opportunities: integrated resource planning (IRP) and levelised costing.

Water conservation offers significant further water savings

DM requires a shift in thinking, from focusing on supplying a volume of water to meeting a water service need. DM therefore begins by identifying the end uses of water, and investigating whether the same or even better quality of service can be provided with a smaller volume of water or perhaps even no water at all. At the most coarse level, water end uses are typically aggregated according to the customer type: unaccounted for water (in effect, where the water utility is its own customer, including system losses and unpaid for water), residential (including single and multi-residential) and non-residential (including institutional, industrial, and commercial users).

Three key factors determine the nature, feasibility and economics of DM opportunities:

1. what kind of customer (*e.g.* residential)
2. what kind of service need is being met (*e.g.* sanitation), and
3. whether the need exists already or is new (*e.g.* retrofitting a 40 year old house or planning for a multi-storey apartment block).

In this section, we draw on our extensive experience in the water industry in Australia and elsewhere to demonstrate the scale of the water conservation opportunities in DM in new and existing residential, and existing non-residential water services. [1]

Existing residential services: Sydney Water's residential retrofit program

In Australia, Sydney Water Corporation (SWC) is a leading DM practictioner. In the residential sector (over 50% of current demand), more than 200,000 households (around 10% of SWC's residential customer base) have taken up the residential retrofit program (SWC 2003:p *vi*) Evaluation of actual savings (Turner *et al*., 2004) shows average single residential savings of 21 kilolitres per household each year (8% of average total demand; 12% of average indoor demand). Combined with multi-residential savings, the residential retrofit program provides savings of more than 4 GLpa at a cost to society of about one-tenth the cost of source substitution options such as recycled water and rainwater tanks.

The remaining residential water conservation opportunity has two dimensions. Firstly, increasing the number of participants: around 90% of existing households have yet to elect to

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[1] In this paper, we focus on actual water services, *i.e.* on residential and non-residential opportunities. Reducing unaccounted for water, leakages, and losses is dealt with elsewhere. See, for example, Lambert (2003).

take up the voluntary offer. Regulatory instruments could help, such as requiring an equivalent retrofit at point of sale: Sydney's real estate has an average turnover of 7 years.

Secondly, increasing the savings from each retrofitted household through improving the *efficacy* of the retrofit (some evaluated savings are lower than anticipated, suggesting that the full potential is not being realised); and improving the *efficiency* of appliances. The recently announced mandatory national water efficiency labelling scheme (Wilkenfeld 2003) needs to be supported by national water efficiency performance standards to deliver real dividends.

And then there are the opportunities in the existing residential outdoor demand, which represents a quarter of all residential use, and has not yet been the subject of a comprehensive investment-based water conservation program.

New residential water services: BASIX

For the same investment, the DM opportunities in new water services are qualitatively and quantitatively better than those available through retrofitting existing services. This is because for new water services, all end uses can be readily targeted and technology choices are not limited by existing plumbing and fixtures.

In a new residential situation, the costs associated with implementing water conservation are close to zero, because only those costs associated with doing something other than business as usual are included. In other words, for new residential services, water conservation costs are only the *difference* in price and installation costs between standard fittings and water efficient appliances. In contrast, for existing housing stock, the full cost of supplying and installing the new fittings should be included in the cost of the water conservation program. So, the same quantum of investment will provide significantly greater water savings (perhaps an order of magnitude) for new residences than for retrofits.

In New South Wales, the Department of Infrastructure, Planning, and Natural Resources (DIPNR) have recently implemented the Building Sustainability Index, or BASIX[2]. This new generation planning tool mandates strong DM targets for all new residential development applications, encompassing 40% reduction in water demand from reticulated potable supply and 25% reduction in energy demand from the grid. Water use calculations undertaken using the BASIX tool (see www.iplan.nsw.gov.au) demonstrate that the water target can be achieved through water conservation alone[3]. With more than 500,000 new homes in the greater Sydney region over the next 25 years (DIPNR 2004 p6), the water savings from this measure alone are substantial.

Existing non-residential services: commercial and industrial

Recent work for the Australian Department of Environment and Heritage identified readily achievable water conservation savings potential of 22 – 40% in their own building stock, including offices, public buildings, and laboratories (Berry *et al*., 2004). When faced with severe water restrictions, industry in central Queensland discovered water conservation savings of 10% from changes in practice with essentially no investment, and savings of 25% at an average cost equivalent to the marginal cost of water supply (Mitchell *et al.*, 2003).

[2] DIPNR invited the Institute for Sustainable Futures to undertake an independent review of the water component of BASIX prior to its release on July 1, 2004.

[3] BASIX calculated water use reductions of 40% and greater encompass the water savings associated with water efficient appliances such as washing machines. Use of these is beyond the control of planning instruments, so these savings are excluded from the planning approvals process.

Unlocking the Potential: a demand management framework

Through our work with water authorities across Australia, we have developed a coherent integrated process that brings together the essential elements to unlock the potential in DM and to compare water conservation options on an equal footing with source substitution and supply options. This process draws on integrated resource planning, and requires conceptual shift in four key areas that distinguish it from current approaches:

1. Build demand forecasts from the ground up using end-use analysis, and account for key changes over time such as in the stock of water-using appliances, rather than projecting forward from a snapshot in time.
2. Develop options focused on addressing local drivers and meeting the expressed service demand, encompassing DM, source substitution, and new supply options, rather than only increasing the commodity supply.
3. Analyse, assess, and compare options on the basis on levelised unit cost of meeting demand, rather than providing supply, incorporating water savings as well as costs and benefits (least cost planning, LCP).
4. Include ‘whole of society’ costs and benefits (avoided and deferred capital and operating costs), rather than focusing on utility costs only (Fane and White 2003). Then undertake financial analyses from utility and other perspectives to decide how best to roll out programs and allocate costs and benefits amongst stakeholders.

Our DM framework is shown in a process diagram in Appendix A, at the end of the paper. In the following section, we describe the basic steps and provide examples of the kinds of outcomes from applying this process to rural, regional, and large urban water utilities.

Applying the DM Framework

Identify drivers and targets

A DM program must respond to local conditions, so the first step is to identify local drivers and targets. These can be categorised as *direct* (e.g. supply security issues because of high population growth rates); *indirect* (e.g. implications of climate change on catchment runoff); or *organisational* (e.g. operating licence targets). For example, Sydney Water Corporation’s operating licence requirement is a key driver, requiring a 35% reduction in per capita flows from storage by 2011, relative to 1991 figures. Understanding the nature of the drivers and targets is imperative because options must respond to local conditions.

Targets can be short, medium, or long term. The best targets are those that result in sustainable water services *e.g.* moving towards water systems where efficiency is maximised throughout, water quality of supply matches the quality required by the end use, investment is in treatment rather than transport, rivers have adequate environmental flows, and communities are engaged in managing water cycles locally.

Collect data

The level of detail of data collected should reflect the stage of investigation. Appendix A shows the wide variety of data and data sources needed for accurate demand forecasting: demographics, water using appliance stocks, end use data, bulk supplies, metered water supplies, other water sources, and so forth. However, for scoping analyses, the detail is unnecessary. For example, two snapshots of annual water use by residential or non-residential sector and locality, along with customer numbers, was enough for Goulburn

Valley Water to decide to focus on existing industrial customers in one supply region and new residential customers in another (Mitchell and Jha 2003).

Build end use model and forecast reference case demand

In interpreting the data into an end use model, there are many potential influences to take into account. Figure 1 shows these, and demonstrates that they include technological, behavioural, and institutional factors.

Clever demand forecasting can identify opportunities for effective intervention to reduce demand. Historically, demand forecasting has entailed taking a snapshot in time, calculating current per capita use, and projecting demand by multiplying this figure by the projected population. This form of demand forecasting is a projection of the present, and traps water utilities into a supply-orientated way of thinking. Far more detailed forecasting is possible using end use analysis. Taking into account the factors shown in Figure 1, end use analysis empowers water utilities to develop a clear picture of how water is used now, and where the opportunities are to intervene.

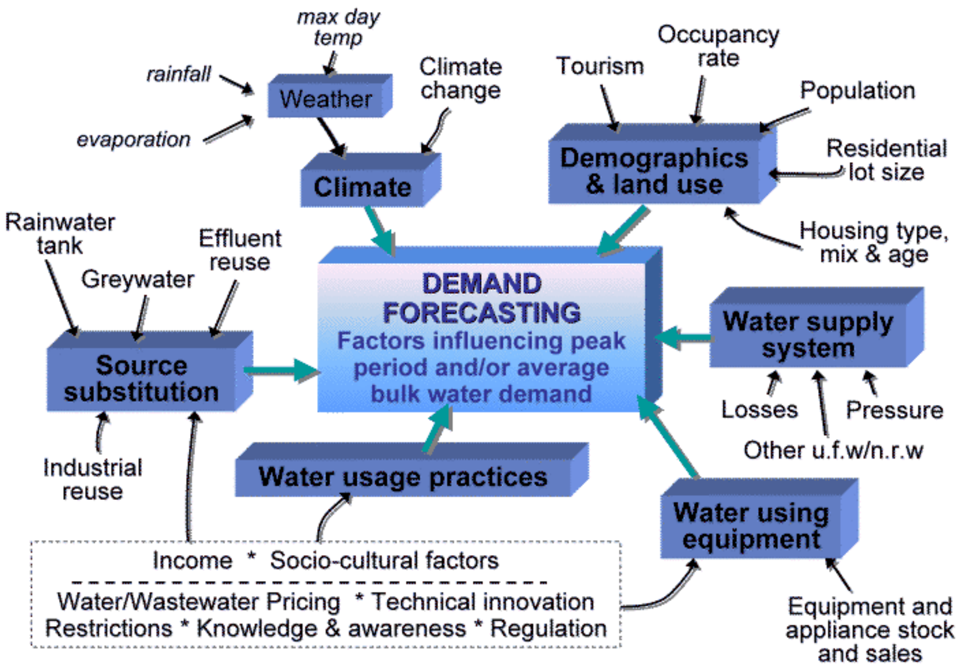

Figure 1 Factors influencing demand (White *et al.*, 2003)

End use analysis and modelling (White *et al*., 2003) entails disaggregating demand into individual sectors (e.g. single and multi residential, commercial, industrial, institutional and unaccounted for water); individual end uses (e.g. for residential - toilets, showers, taps, dishwashers, washing machines, outdoor gardens, swimming pools); the stock of houses and appliances in a specific region (e.g. single and multi residential households, AAA rated showerheads, 6/3 litre dual flush toilets); and how people use their appliances and therefore how much water they use. Each area is different (*i.e.* single residential households in Alice Springs use approximately 2.5 times as much water as households in Sydney (Turner *et al.*, 2003)) and thus region-specific data is critical in order for the model to accurately reflect 'real life' now, and reference case demand in the future, and the impact of DM interventions.

Devise and analyse options

DM options need to incorporate two basic elements: a measure and an instrument. A measure is 'what to do' (*e.g.* install a water efficient showerhead) and an instrument is 'how to do it'. There are three kinds of instruments for implementing water conservation measures: regulation (*e.g.* planning controls, minimum water efficiency regulations on appliances sold); communication (*e.g.* a targeted education campaign); and economic incentives (*e.g.* a subsidised retrofit program, rebates on raintank installation). The choice of measure, instrument and timing is significant because it dramatically affects uptake and participation rates, and therefore water savings and cost savings.

Water utilities can now choose from a plethora of demand management options that have been implemented in Australia and around the world. Typical options include: indoor residential retrofits; subsidised outdoor garden assessments and free giveaways; showerhead and toilet rebates; business audits/retrofits; schools programs; education and community awareness programs; water pricing reforms such as inclining block tariffs; labelling and minimum water efficiency performance standards; regulations on garden watering practices; short term restrictions; leakage detection and pressure reduction etc. The list is vast and growing as water authorities around the world combine their knowledge in finding new ways of reducing demand (*e.g.* through IWA's international DM and efficiency conference series).

Once analysed, a supply curve can be generated, where the DM options are ordered in terms of their unit cost. Figure 2 shows an example from a recent study for the Australian Capital Territory (Turner and White 2003).

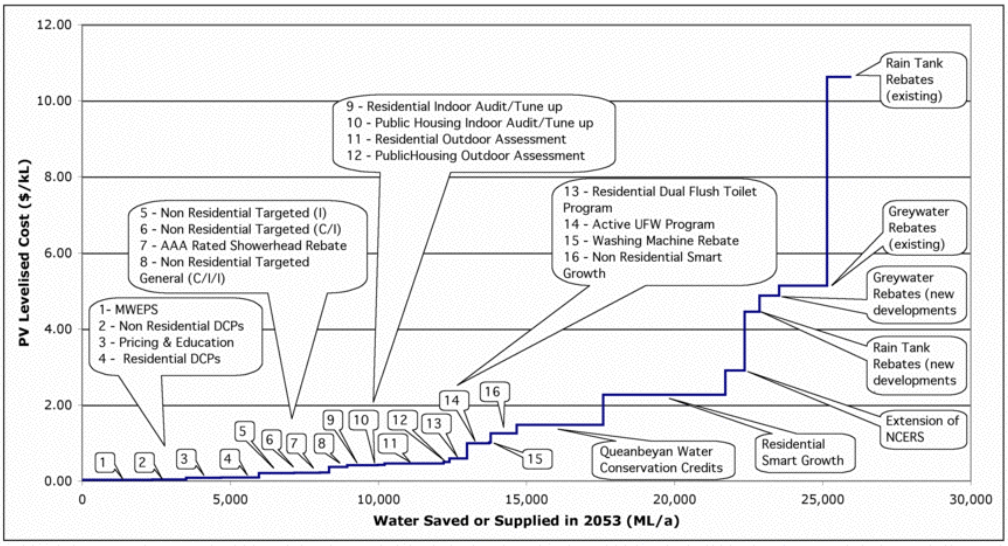

Figure 2 Typical supply curve for DM options (Turner and White, 2003)

The supply curve shows the cumulative water saved and supplied against the present value levelised cost of each option. Options are ordered in terms of least cost, ranging from low cost water conservation options (MWEPS – minimum water efficiency performance standards) to high cost raintank rebates. This exemplifies the pattern of lower cost water conservation options and higher cost source substitution and source augmentation options.

Implement and Evaluate Program

Supply curves provide utilities with an effective process to order their investment in DM options, directing implementation. Because the options combine both technological and behavioural components, and because the option analysis revolves around predicting take-up rates and water savings, evaluation of the actual results is essential. Evaluation will provide higher certainty in the modelling outcomes. In addition, water use can be strongly influenced by wide-ranging external events, from droughts to changes in government, so re-evaluation of the DM program is essential to ensure its relevance and impact.

Conclusions

Water conservation still holds enormous potential. It provides 'new' water supply at a cost to society lower than that of source augmentation or source substitution, and at a lower resource use intensity *i.e.* it saves materials and energy required for treatment, distribution, use and collection. What is needed for it to reach its potential is a clear approach that enables water utilities to unlock its potential, and confidently build it into planning processes. In this paper, we have outlined such a process, and provided examples from urban, regional, and rural Australian water utilities that have benefited from its use. The key is for water authorities to identify the real local drivers, and to be able to disaggregate current water use in order to identify where best to intervene and invest first.

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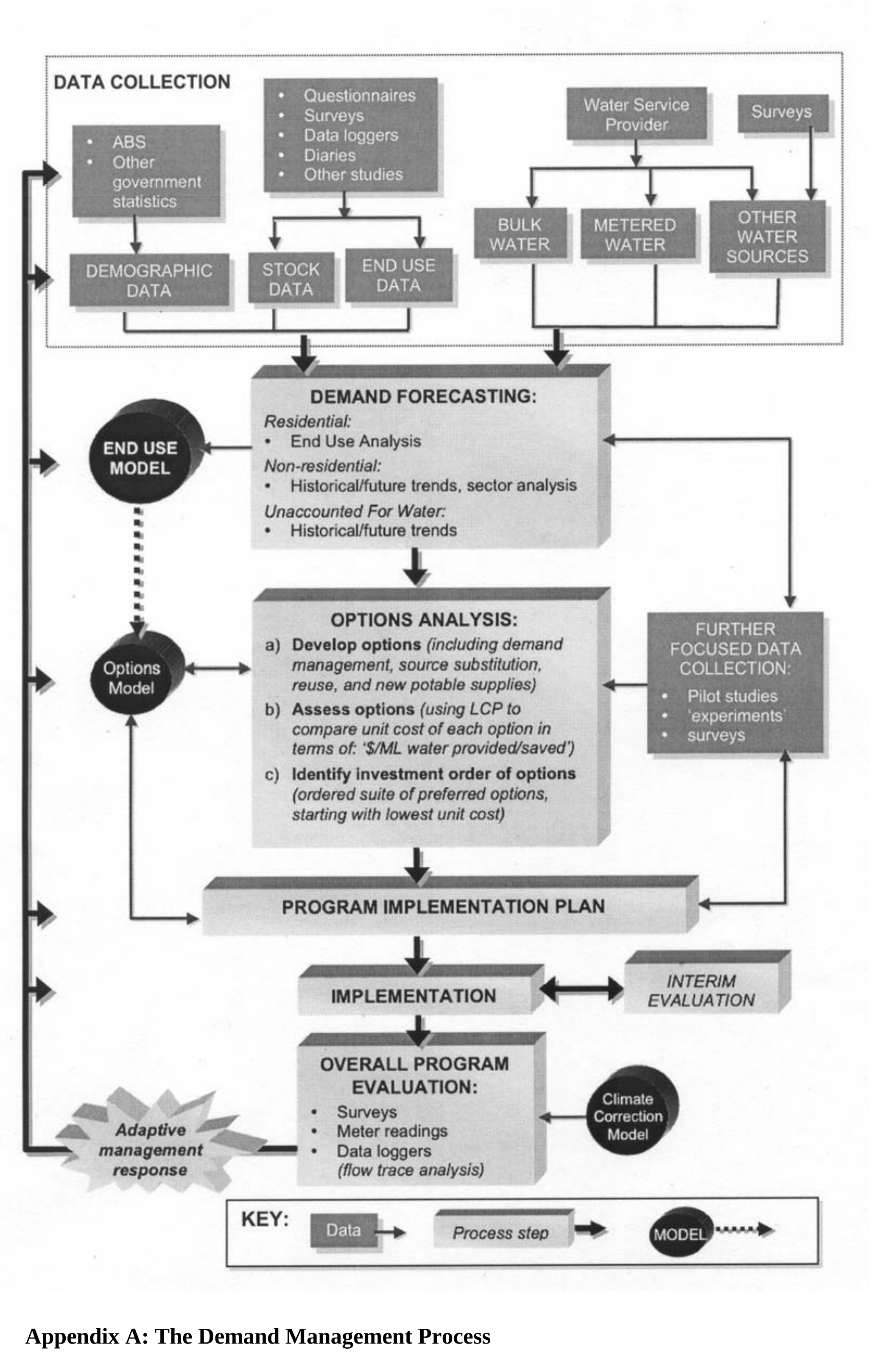

Appendix A: The Demand Management Process